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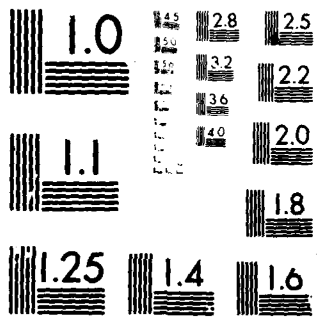

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ALTERNATE CV FLIGHT DECK ARRANGEMENTS

CENTER FOR NAVAL ANALYSES
1401 Wilson Boulevard
Arlington, Virginia 22209
SYSTEMS EVALUATION GROUP

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May 1977

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Prepared for:

OFFICE OF NAVAL RESEARCH
Department of the Navy
Arlington, Virginia 22217

OFFICE OF THE CHIEF OF NAVAL OPERATIONS (Op96)
Department of the Navy
Washington, D.C. 20350

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER: 14) CRC-332 / 2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): 6) Alternate CV Flight Deck Arrangements	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): 10) Peter L. Willson [redacted] Robert W. Covey [redacted] Thomas F. Donnelly, ~~USN~~	8. CONTRACT OR GRANT NUMBER(s): 15) N00014-76-C-0001
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Center for Naval Analyses, 1401 Wilson Boulevard, Arlington, Virginia 22209 — 12) 17	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: Office of Naval Research, Department of the Navy, Arlington, Virginia 22217	12. REPORT DATE: 11) May [redacted]77
	13. NUMBER OF PAGES: 11
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): Office of the Chief of Naval Operations (Op96), Department of the Navy, Washington, D.C. 20350	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

aircraft carriers, carrier landings, conceptual CV (CCV), flight decks, hangar decks, ships

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report proposes flight and hangar deck layouts for carriers that would take advantage of the design opportunities offered by nuclear power. The arrangement proposes, among other things, a recovery area located amidship, an island located on the stern, and a bilevel hanger bay.

Benefits of the new arrangement include improved operational efficiency, safety, and cost. The conceptual CV (CCV) would provide a more efficient airfield than exists on present carriers. Several factors contribute to this expected increased operational efficiency: improving the flow pattern of aircraft on the flight deck; increasing the rate of aircraft landings; enhancing administration of the flight deck; and permitting air operations in higher sea states.

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Because the proposed flight deck permits redesigning the hangar bay, the ships' aircraft capacity can be increased.

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INTRODUCTION

The general flight deck arrangement of most carriers (launch area forward, landing area aft, and the island amidships on the starboard side) has remained essentially unchanged over the years. Improvements such as hurricane bows, catapults, deck-edge elevators, and angled decks have been made; however, these improvements were added to existing designs rather than integrated to provide an entirely new design. The present flight deck arrangement was designed, to a great extent, to take the propulsion system into account. It was necessary to locate heavy, fossil-fueled, steam generating power plants near the center of the hull. The power plant location, in turn, determined the location of the exhaust and air ducting systems. Stacks were located almost directly above the boiler to maximize duct efficiency and minimize the amount of ship's volume dedicated to ductwork. The island structure was generally built around the stacks to minimize the number of above-deck structures on the flight deck. Modern propulsion systems, such as nuclear power, do not require stacks near the hull center. Thus, the island location can be based on other considerations.

This report proposes flight and hangar deck layouts that would take advantage of the design opportunities offered by nuclear power. The layout may not be compatible with fossil-fueled power plants because of their venting requirements.

FLIGHT DECK PROPOSAL

The proposed flight deck layout is shown in figure 1. The island structure is on the stern and the landing area is on the port side amidships at an angle opposite to that in present CVs. Landing runout would be forward onto the bow. The launch area is on the bow as on present carriers. This arrangement appears to offer improved operational efficiency, safety, and cost. It also permits redesigning the hangar bay to increase the number of aircraft that can be embarked.

Operational Efficiency

The conceptual CV (CCV) would provide a more efficient airfield than present carrier designs. The increase in operational efficiency would result from: improving the flow pattern of aircraft on the flight deck; increasing the rate of aircraft landings; enhancing administration of the flight deck; and permitting air operations in higher sea states. Each of these improvements is discussed below.

Aircraft Deck Flow

The carrier deck cycle is the repetitive process of launching and recovering groups of aircraft. During the cycle, the flight deck serves as a runway, taxiway, and parking ramp. On current CVs, different portions of the flight deck perform different functions at different times. During launch, for example, the recovery area is used as a parking ramp and taxiway.

When all aircraft have been launched, the landing area is cleared by towing the remaining aircraft forward onto the area previously used as a takeoff runway. During the recovery, aircraft taxi from the landing area, and the launch area becomes the taxiway and parking ramp. Once the recovery is completed, the launch area is filled with parked aircraft that must be moved to the landing area to begin the cycle again. One characteristic of the deck cycle is a flow forward, a halt, and a flow aft during each period of the cycle.

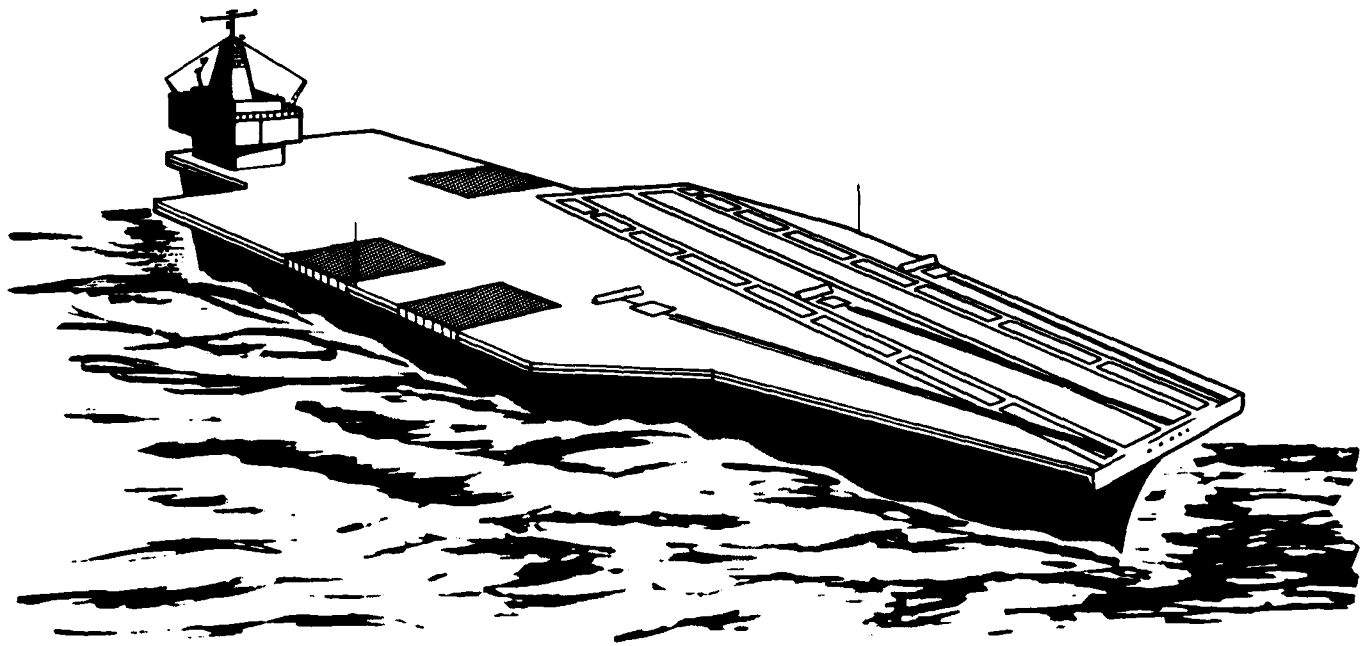


FIG. 1: A CONCEPTUAL CV (CCV)

The movement of aircraft back and forth is not the only activity occurring during the cycle. The aircraft must be inspected, rearmed, refueled, repaired, and serviced. Because the last aircraft recovered is usually the first to move back, other operations must sometimes be interrupted for the respot. The respot is often not complete by the time the Air Officer directs the starting of engines.

The respot requires a considerable number of men and a large amount of equipment. Moving an aircraft requires a tractor driver, a director, a safety observer, a brake rider, and men to pull the chocks and release the tie-down chains as well as insert the chocks and install the chains. A tow bar and tractor are required for each aircraft in movement at any one time.

The flow of aircraft between launches would be significantly changed on the CCV (figures 2, 3, and 4). After an aircraft was arrested, it would be turned out of the landing area and taxied aft into the parking area. The aircraft would be serviced, rearmed, refueled, and repaired in the parking area. Because the launch area is also the landing area, few aircraft would be respotted. The aircraft would be manned, engines started, and preflight items completed in the same spot where the aircraft was taxied after the last flight. The time used to respot aircraft on today's CVs could be used effectively for other tasks. In addition, maintenance that cannot be conducted on parked aircraft during landing operations on present CVs could continue in the parking area on the CCV.

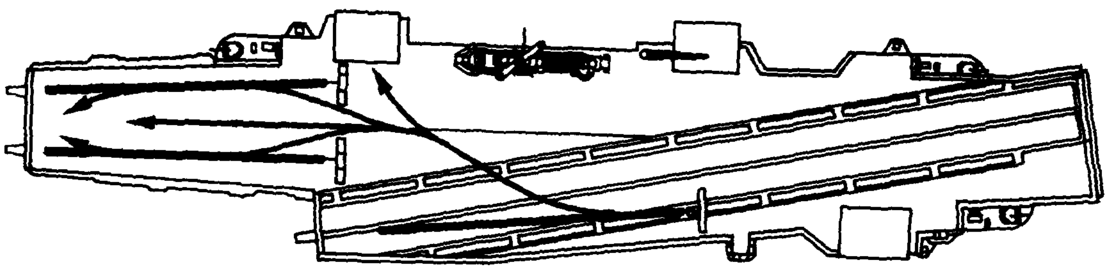
Boarding Rate

The pitching and heaving motion of the ship often causes problems during aircraft recovery operations. Deck space must be provided aft of the arresting wires as a margin of safety for pilot errors and deck movement. At times, an aircraft must abort a landing either to avoid the ramp or a relative vertical speed that would exceed the aircraft's allowable sink rate. Bolters[1] can also be caused by the motion of the deck. Also, there are times when the deck (and especially the aft-located landing area) moves so violently that air operations are halted.

The touchdown point on the CCV should be more stable than that on today's decks. Normally, the directions of the wind and sea are nearly parallel. Therefore, the deck motion of a carrier heading into the wind is largely pitch and heave rather than roll and heave. The pitch-induced motions of a carrier's bow and stern have large amplitudes and large tangential velocities because of the long lever arm (see figure 5). The CCV's landing area has a short longitudinal lever arm; its motion should be much less violent than the landing area on today's ships.

Roll motion would have a larger effect on the CCV's touchdown point than it does on today's decks. The effect of roll on the CCV should, however, be much less than the effect of pitch on today's decks for several reasons: (1) most of the motion is pitch because the directions of the sea and wind are nearly parallel; (2) the amplitude of roll motion is less than the amplitude of pitch motion because the transverse lever arm is much shorter than the longitudinal lever arm; and (3) the instantaneous tangential velocity of the CCV landing area would be less than that of today's decks because of the shorter transverse lever arm. The tangential velocity statement follows from reference 1 where it was shown that the periods of roll and pitch motions for Forrestal class carriers are approximately the same. Unfortunately, the strength of the coupling between heave and roll is not known. If heave-induced roll were a problem for the CCV, further improvements could be made by equipping the ship with either roll stabilizers or anti-roll tanks.

[1] The aircraft's tail hook does not engage an arresting wire.



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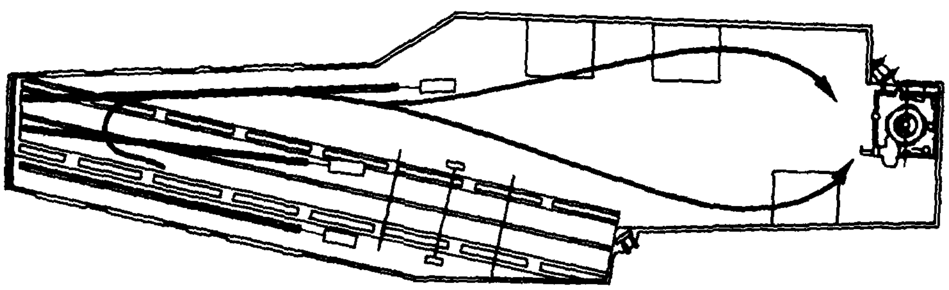
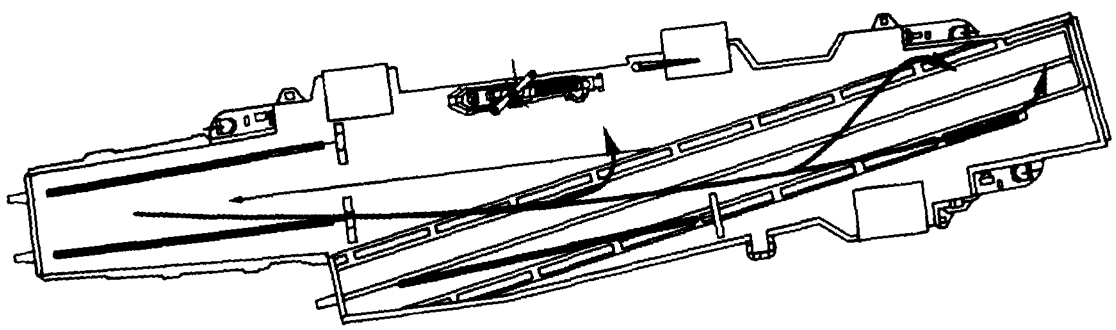


CCV

FIG. 2: RECOVERY FLOW ON A CV AND THE CCV



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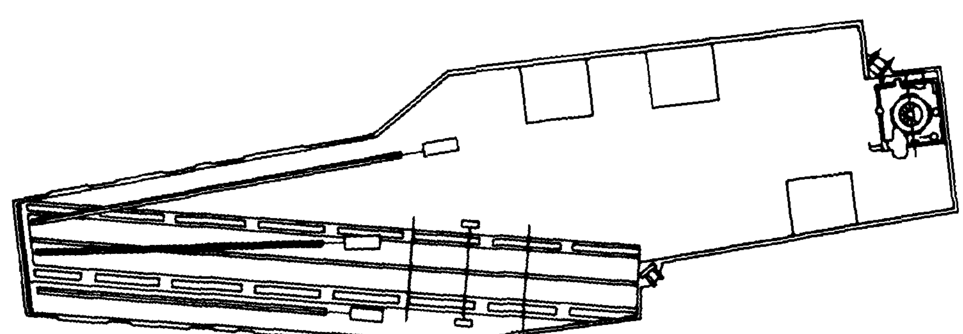
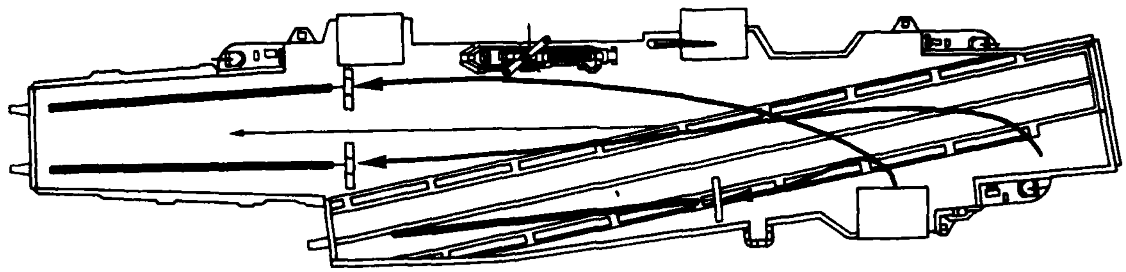


(minimal respot required)

CCV

FIG. 3: RESPOT FLOW ON A CV AND THE CCV



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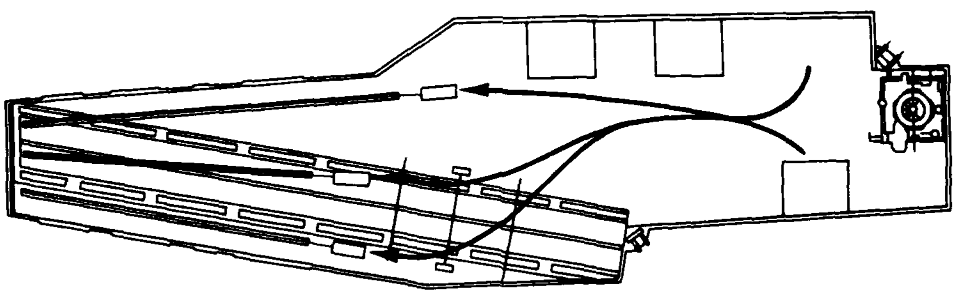

CCV

FIG. 4: LAUNCH FLOW ON A CV AND THE CCV

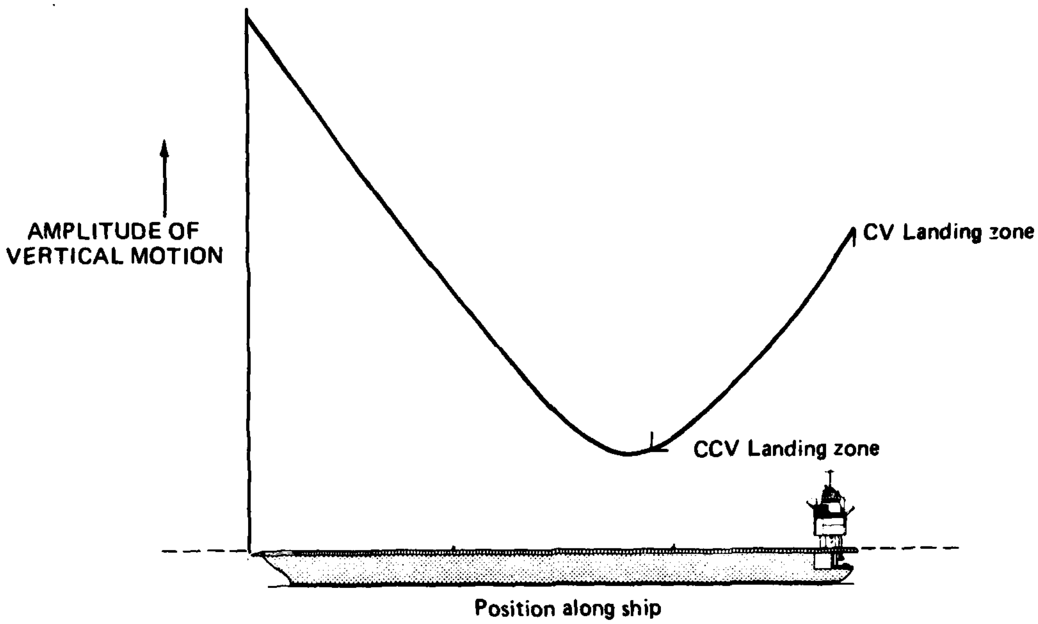

FIG. 5: VERTICAL MOTION ON AN AIRCRAFT CARRIER

The boarding rate is also affected by the carrier's overall shape. The air flow around the ship creates turbulence and eddies that can make landing an aircraft more difficult. For example, the angle in the deck at the forward end of the landing area on today's carriers creates a vortex and the island structure causes a turbulent wake that is felt in the aircraft as a "hole" just before touchdown (reference 2).

Movement of the island structure aft would minimize the effect of turbulence from the island. Elimination of the angle at the forward end of the landing area would change the air flow pattern in the path of aircraft landing on the CCV; the effect of this change could not be evaluated.

Flight Operations

The enhanced stability of the touchdown area would improve boarding rates for air operations in normal sea conditions; it would also make it possible to conduct flight operations in higher sea states. A high sea state would not force the termination of flight operations as frequently as it does today.

Flight Deck Management

The CCV would improve flight deck management by giving an unobstructed view of the entire flight deck from the island structure. Personnel charged with flight deck administration, such as the aircraft handling officer, could directly observe events as they occur.

Safety

The CCV deck appears to offer benefits in terms of aircraft and personnel safety.

Landing Safety

The same factors that improve boarding rates should also decrease the number of landing accidents, especially if the distance from ramp to arresting gear is the same as in current CVs. In fact, the reduced vertical movement of the landing ramp may permit the distance between the ramp and arresting gear to be shortened without increasing the landing accident rate. If so, additional deck space would be available for other purposes.

Emergencies

Except during scheduled landing operations, aircraft cannot land on a conventional carrier until the landing area has been cleared of parked aircraft. Aircraft with emergencies must either wait for the parked aircraft to be cleared from the landing area[1] or divert to another carrier or a field ashore. On the CCV, the landing area is not used for aircraft parking, and is ready to recover aircraft at all times.

Crash Danger

The wreckage from a landing accident on a conventional carrier usually moves forward on the ship. It can damage parked aircraft and injure personnel. On the CCV, debris from a crash has a clear path off the ship.

Handling Accidents

With fewer movements of aircraft during the landing-maintenance-takeoff cycle, the aircraft are less exposed to the possibility of spotting and respotting accidents.

Cost

The CCV flight deck should reduce both investment and operating costs. The flight deck could be operated by a smaller deck crew with less equipment than today's carriers. Therefore, the ship would need fewer personnel accommodations, and the total outlay for salaries and other personnel costs could be decreased. Parking aircraft in a single area on the ship would also decrease the CCV's cost because some servicing facilities would not be unnecessarily duplicated.

Disadvantages

The views of the bridge watch and conning officer from the CCV island would be restricted in the areas directly forward of the ship and close aboard on both sides. That could make docking and undocking as well as underway replenishment more difficult. Secondary or specialized steering stations might be needed to increase visibility when coming alongside a pier or replenishment ship. Television or infrared system might also help alleviate the visibility problem.

The conceptual ship has 3 elevators. Lack of a fourth elevator means that 1 hangar bay is served by a single elevator. A fourth elevator could be added at a cost of approximately $20 million (in 1979 dollars).

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[1] Clearing parked aircraft from the landing area on a "pull forward" for emergency recovery of aircraft takes time and disrupts the cycle of the deck. The disruption also affects subsequent launches.

Absolutely simultaneous launch and recovery of aircraft would not be possible on the CCV flight deck, though near simultaneity would be. An aircraft can be spotted on the starboard catapult during recovery; it could be launched immediately after a recovering aircraft had cleared the foul line.

It would probably take longer for an aircraft to clear the CCV landing area after arrestment. This could result in a longer recovery time and have the carrier steaming into the wind for a longer period; however, because wire retraction and arresting engine preparation are currently the constraints on landing interval, the extra time needed to taxi clear of the landing area should be small. Tests would be required to determine the magnitude of this effect.

HANGAR DECK PROPOSAL

The proposed flight deck also permits redesigning the hangar bay to increase its aircraft capacity. Unlike today's carriers, the aft portion of the flight deck is not subject to the impact of landing aircraft. The reduction in dynamic loading should permit the depth of the structure to be decreased. In addition, there is no requirement to house airfield machinery such as arresting machinery in a gallery deck in this area. The ship's volume, freed by making these 2 changes, could be used to build an intermediate hangar deck between the main deck and the flight deck.

Figure 6 shows the geometry of the proposed hangar configuration. The flight deck height above the hangar deck is increased from the present 36.5 feet to 40 feet. A 4-foot-deep space frame structure supports the aft part of the flight deck; normal bridge girder structure supports the rest. A 1-foot-thick hangar deck is suspended midway between the bottom of the space frame and the aft main deck hangar bay. Deck-edge elevators serve the flight deck, the mid-deck hangar, and the main deck hangar. The forward main deck hangar lies under bridge girder construction. As in current CVs, the intergirder space would be used as a gallery deck. The forward bay would have an overhead clearance of about 29 feet. Modularly loaded stores, work centers, shops, or berthing spaces could be suspended from the gallery deck where an overhead clearance of 21 feet is acceptable.

Aircraft-Carrying Capacity

The additional hangar level would increase the aircraft parking area by approximately 50 percent in the hangar bay. Total aircraft capacity would be increased by about 25 percent. The additional space would permit embarking the *entire* CV air wing rather than a portion of it. Today, a portion of the wing is based ashore because of space limitations on the ship. The CCV would have the full variety of aircraft aboard to meet any particular mission assignment without having to swap shore-based aircraft for embarked aircraft.

Effect on Maintenance

The overhead in the bilevel hangars (17.5 feet) would be lower than that in USS Forrestal and later classes of CV. Aircraft could not be put on jacks on the bilevel bays because of the low overhead. Aircraft are jacked for calendar inspections and for repairing landing gear malfunctions and some hydraulic leaks. Maintenance actions that require jacking are relatively infrequent and could be done in the forward (high) hangar bay.

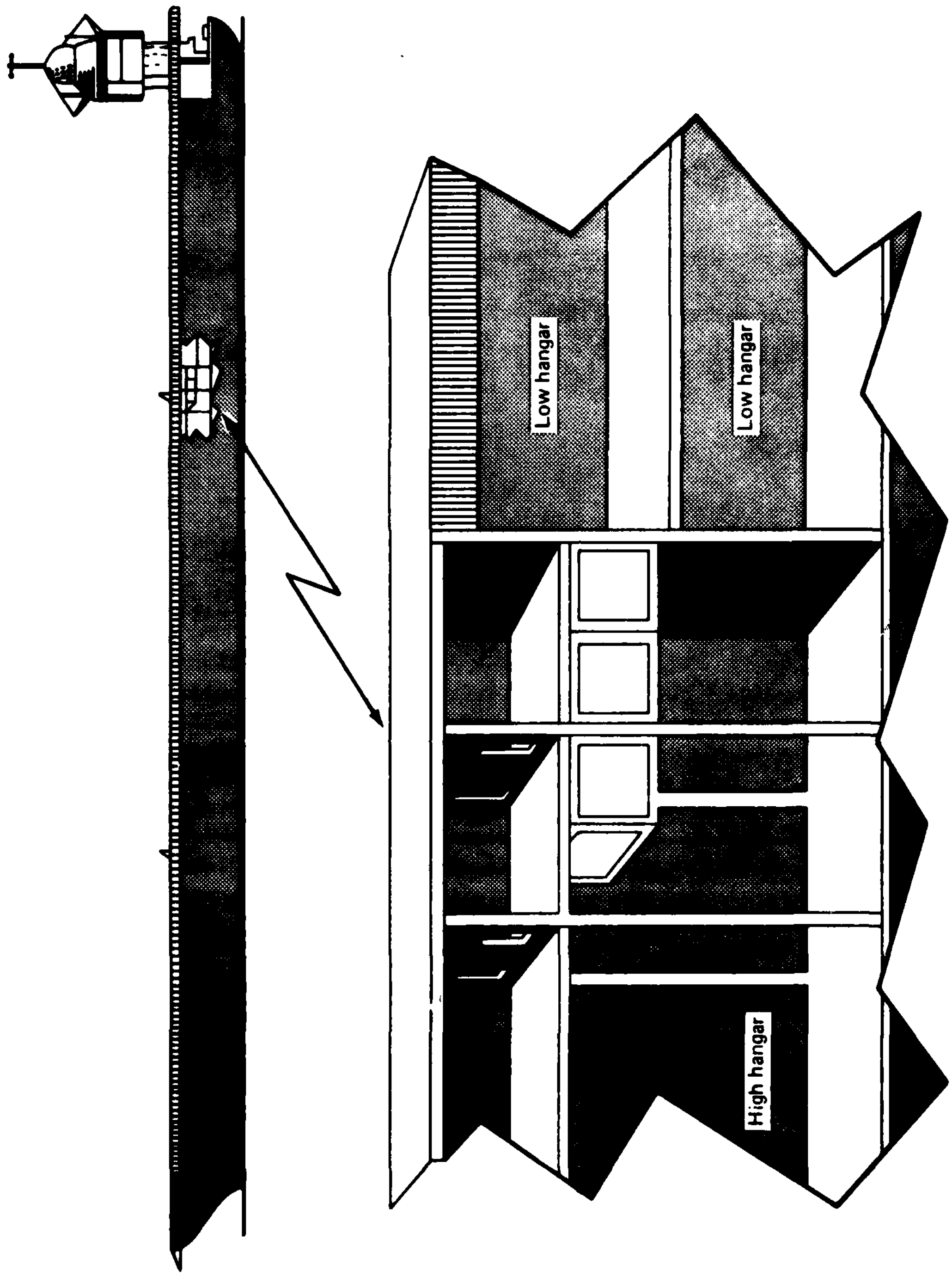

FIG. 6: CCV HANGAR ARRANGEMENT

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1. Systems Technology, Inc., Report No. 137-3, "Analysis of Aircraft Carrier Motions in a High Sea State," Unclassified, Mar 1969

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